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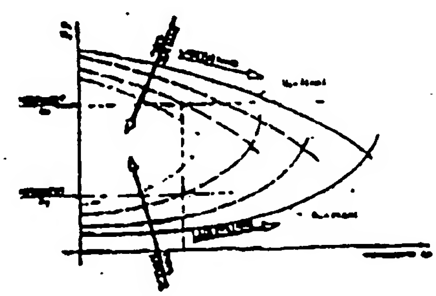
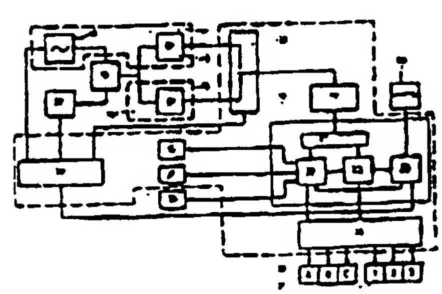
(54) Test procedure for d.c. sources like storage batteries and testing device for it

(57) A testing procedure and a testing device for carrying out this procedure for d.c. sources like batteries is indicated, which enables a distinct identification of the condition of the tested unit by a single test process and without additional charging of the d.c. source (10) being tested, while at the same time indicating whether a discharging or a physical condition (storage capacity) is responsible for the "bad condition" of the tested unit. For this, one measures the a.c. internal resistance (R_S) and the no-load voltage (U_B) of the tested unit (10) and by combining the measured values of the no-load voltage U_B, on the one hand, and the internal resistance R_S, on the other, in correlated characteristic functional relations of the no-load voltage as a function of the ampere-hour capacity [$U_B = f\ (Ah)$] or the a.c. internal resistance as a function of the ampere-hour capacity [$R_S = f\ (Ah)$] for different physical states (storage capacity) of a d.c. source of the same type as the tested unit (10) one obtains a separate verdict on the charge state, on the one hand, and storage capacity, on the other.





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Röser

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Test procedure for d.c. sources such as accumulators, batteries or the like, and testing device

State of the Art

The invention proceeds from a testing procedure for d.c. sources, such as accumulators, batteries or the like, according to the category of the main claim.

In a procedure employed in a known testing device, one determines from the measured a.c. internal resistance of the d.c. source being tested, known as the tested unit, the reciprocal of the a.c. internal resistance and displays this on a meter. Since the reciprocal a.c. internal resistance of the tested unit is proportional to its dynamic power and this, as has been found - roughly reflects the electrical energy that is actually stored in the tested unit, the indicated value of the reciprocal a.c. internal resistance constitutes a measure of the state of the tested unit.

Now, it turns out that the dynamic power, e.g., of a storage battery or an automotive battery, decreases considerably both with increasing discharge and with increasing impairment of the physical condition - by aging, sulfating, etc. By physical condition is meant here the storage capacity of the battery. For example, the dynamic power decreases by a factor of 3-4 during the discharging of the battery from the fully charged state to the state of total discharge. The dynamic power of an accumulator or a battery that was discharged for several months before being recharged also increases by a factor of 3-10, due to intensified sulfating.

In this known testing procedure or testing device, one only gains information on the actual condition of the tested unit, but one does not know whether this "bad" actual condition of the tested unit is caused by the tested unit being only at least partly discharged, or whether it has lost some or all of its original storage capacity by aging, sulfating, or other circumstances. This means that, whenever a "bad" condition of the tested unit is determined, it is charged, even when a charging of the unit is no longer advisable due to its extremely bad physical condition, e.g., total loss of its storage capacity. Only this charging of the unit and a new test reveal that the "bad"

actual condition of the unit is caused by its poor physical condition; since the charging eliminates the other possible cause of the "bad" actual condition, namely, partial discharge. The oftentimes unnecessary charging of a defective battery in order to establish that it is defective involves a needless and not inconsiderable loss of time and expenditure.

Advantages of the Invention

The testing procedure according to the invention with the characterizing features of the main claim has the advantage that the tested unit need not be charged in order to determine its physical condition, i.e., its actually available storage capacity. In the testing procedure according to the invention, both the charge state of the tested unit, such as full, partly discharged, or empty, and the physical condition of the unit are determined, so that the tester immediately knows whether or not a charging of the unit is advisable, due to its physical condition. This can save the expenses of a possibly needless charging and the associated loss of time.

The testing device indicated in Claim 2 to carry out the procedure has, besides the already above-mentioned advantages, the further advantage of easy handling and operability. The tester needs only connect the tested unit to the device and start a testing procedure. The test result is put out to him on the display device, namely, the physical condition of the tested unit on the one hand, and its charge condition on the other. At a glance, therefore, the tester can realize whether the unit needs to be charged and whether or not the qualitative condition of the unit justifies charging it.

The measures indicated in the other claims enable advantageous developments and improvements of the testing device. Especially advantageous here are the measures per Claim 10 or 11, for in this way the structural volume of the testing device can be very small in size, and the manufacturing costs of the testing device can be kept low.

Drawing

A sample embodiment of the invention is presented in the drawing and explained more closely in the following description. This shows

Figure 1 a schematic depiction of functional relations of the no-load voltage U_B in dependence on the ampere-hour capacity Ah or the a.c. internal resistance R_S in dependence on the ampere-hour capacity Ah for an automotive battery of particular type.

Figure 2 a block diagram of the layout of a testing device for testing an automotive battery.

Description of the sample embodiment

First the testing procedure for d.c. sources such as accumulators, batteries, or the like, shall be briefly sketched by means of figure 1, based on the testing of an automotive battery, which will then be further explained in the subsequent description of the testing device. In the testing

procedure, one first determines the a.c. internal resistanc R_S of the automotive battery being tested, hereafter called the tested unit, and measures its d.c. no-load voltage U_B. These two measured values are combined - as can be seen from figure 1 - in mutually correlated characteristic functional relations of the no-load voltage U_B in dependence on the ampere-hour capacity Ah and the a.c. internal resistance R_S in dependence on the ampere-hour capacity Ah for each different physical condition of an automotive battery of the same type as the tested unit. Such characteristic functional relations can be represented as characteristic fields figure 1 or as approximated mathematical functions.

Thus, figure 1 shows, for an automotive battery of the same type as the tested unit, i.e., same rated capacity, rated voltage, and same structural design (e.g., lead storage battery or nickel-cadmium storage battery), its characteristic functional relations $U_B = f$ (Ah) and $R_S = f$ (Ah) as a characteristic field. Correlated functional relations are each characterized by the same type of line. The unbroken characteristic lines here represent the corresponding characteristic functional relations for a new battery. One notes that with increasing discharge, the d.c. no-load voltage U_B of the battery decreases and the a.c. internal resistance increases. For the same, but aged battery, one gets the characteristic functional relations according to the dash lines. If the battery is aged even further, i.e., its storage capacity has further decreased by progressive sulfating, one gets the characteristic functional relations according to the dot and dash lines. The same battery in relatively poor physical condition is characterized in its characteristic functional relations by the dotted lines. One sees that with worsening of the physical condition of the battery both the no-load voltage U_B decreases and at the same time the a.c. internal resistance R_S increases. The individual characteristics $U_B = f$ (Ah) and $R_S = f$ (Ah) essentially preserve their characteristic trend as described above.

If, now, one combines the two measured values found for no-load voltage U_B and a.c. internal resistance R_S in correlated characteristic functional relations $U_B = f$ (Ah) and $R_S = f$ (Ah) for the same ampere-hour capacity Ah removed (represented in figure 1 by the intersections between the measured value lines and the associated characteristics), one obtains a separate statement, on the one hand, as to the charge condition of the tested unit (ampere-hour capacity Ah removed) and, on the other hand, as to the physical condition or the storage capability of the tested unit (dot and dash line = relatively poor).

The testing device for d.c. sources such as accumulators, batteries, or the like, to carry out the above-described testing procedure, is schematically shown as a block diagram in figure 2. Here, the automotive battery to be hooked up for testing to the device, hereafter known as the tested unit, is designated by 10.

The testing device has a resistance meter 11 for measuring the a.c. internal resistance of the tested unit. This consists of a constant-current generator 12 and a voltage amplifier 13. The constant-current generator 12 is connected to the terminals of the tested unit 10 and feeds it a constant current of very low intensity and constant frequency, preferably 100 Hz. The voltage amplifier 13 is configured as a selective amplifier tuned to the frequency of the constant-current generator 12, and it also contains a direct current gate. The voltage amplifier 13 is likewise connected to the terminals of the tested unit 10 and it detects and amplifies the alternating

voltage drop at the terminals of the tested unit 10.

The testing device, moreover, has a voltage measuring system 14, which basically consists of a d.c. amplifier 15. This is likewise connected to the terminals of the tested unit 10. To improve the voltage measurement, the d.c. amplifier 15 can also receive an offset voltage.

The testing device also has a first memory 16, which saves the characteristic functional relations of the no-load voltage U_B and the ampere-hour capacity Ah of at least one automotive battery of the same type as the tested unit for each selected different physical condition of same. As already mentioned above, by physical condition is meant here the storage capacity of the battery, which can decline from that of a new intact battery by aging process, especially as a result of sulfating or grounding or by other circumstances. In order to allow universal use of the testing device, the above-mentioned characteristic functional relations are saved in memory not just for one battery type, but for all customary battery types. Likewise, in a second memory 17, the characteristic functional relations of the a.c. internal resistance R_S and the ampere-hour capacity Ah are saved for each of the same selected conditions as the functional relations in the first memory 16. The functional relations here can be saved either as characteristic fields or as approximated mathematical functions. It is advantageous to normalize the individual characteristic functional relations, and this preferably to the rating values, in order to reduce the number of relations memorized. For all batteries of the same kind, lead or alkaline accumulators, but different rated capacity and rated voltage, it is then enough to memorize a single characteristic field or a few mathematical functions for each of the different physical conditions.

The two measuring devices, i.e., resistance measuring unit 11 and voltage measuring unit 14, and the memories 16, 17, are connected to an operator 18, which preferably works digitally and can be configured as a microprocessor. Since the measured values of the measuring units 11, 14 are put out as analog signals, these must be converted into digital values for processing in the operator 18. An analog/digital converter 19 hooked up between the measuring units 11 and 15 and the operator 18 serves for this. In order to make do with a single analog/digital converter 19, an analog switch 20 is connected upstream from it, and it alternately feeds an analog measured value signal from the resistance measuring unit 11 or the voltage measuring unit 14 to the analog/digital converter 19. The analog switch 20 is connected by both its inputs to the outputs of the voltage amplifiers 13, 15 and its output is connected to the input of the analog/digital converter. The digital measured-value signals supplied to the operator 18 via the analog/digital converter 19 are kept in a cache memory 21 of the operator 18 until the end of a testing procedure.

The operator 18 has a calculator 22 and a comparator 23. The calculator 22 calculates or determines, for the measured no-load voltage of the tested unit 10 arising as a signal at the input of the operator 18 or in its cache memory 21, an assigned value of the a.c. internal resistance R_S from the relations saved in memory and furnishes this as output signal to the comparator 23. By one output of the operator 18, the comparator 23 is connected to a display device 24. Besides the output signal of the calculator 22, the comparator also receives as input signal the value of the measured a.c. internal resistance arising as a signal at the operator 18 or in its cache memory 21. The comparator 23 now works such that, if its two input signals coincide or essentially

approximately coincide, it puts out an output signal to the display device 24, which in turn activates a display function.

The operator 18, furthermore, has a controller 25 connected to the comparator 23 and the calculator 22. This controller 25 is constructed such, and connected to the comparator 23 and the calculator 22 such, that when the input signals of the comparator 23 do not coincide or approximately coincide, the latter puts out a signal to the controller 25, which triggers a control signal here. This control signal of the controller 25 causes the calculator 22 to carry out a calculation or determination cycle, as described above, while at the end of each individual cycle an output signal is put out to the comparator 23. However, these calculation or determination cycles are not identical, but instead occur with the memorized relations for a particular physical condition of the battery. During each cycle, a memorized relation for a particular physical condition of the battery is read out from the memory 16, 17 and processed. The first cycle advisedly starts with the relations for the best physical condition of the battery.

In order to enter the characteristic data of the tested unit 10 into the calculator 22, a data entry device 26 is connected to the operator 18. Through this data entry device, the rated capacity, the rated voltage, and the type of tested unit 10, e.g., lead or nickel-cadmium battery, are entered. Furthermore, the temperature of the tested unit can also be entered, to eliminate temperature influences.

In order to compensate for measurement errors, which may be caused by surface charge of freshly charged tested units or by defective cell connectors in the tested unit, a high-current pulse generator 27 is additionally connected to the tested unit 10, which applies a high-current pulse to the tested unit 10 before the actual testing procedure begins. This high-current pulse has, for example, a current intensity at the magnitude of the load current of the tested unit and a duration of several seconds. This high-current pulse, first of all, gets rid of the surface charge of a freshly charged tested unit and, secondly, tests its cell connectors. If these are already very bad, they will be completely disrupted by the high-current pulse.

The testing device is outfitted with a time switch 28, which determines the "timing" of the individual processes during the testing procedure. The time switch 28 is connected to the high-current pulse generator 27, the constant-current generator 12, the analog converter 20 [sic!] and the operator 18. A starting pulse for the testing procedure, furnished by a starter 29 to the operator 18, sets the time switch 28 in operation. This brings about the switching on and off of the high-current pulse generator 27 and the constant-current generator 12, as well as the switching of the analog switch 20 for the alternating transmission of the analog measured-value signals at the output of the voltage amplifiers 13 and 15 of the resistance measuring unit 11 or the voltage measuring unit 14 to the analog/digital converter 19.

It is possible to assemble the operator 18, the two memories 16 and 17, which moreover can be formed by a single memory, the analog/digital converter 19, the analog switch 20, the time switch 28, and at least parts of the display unit 24 into a so-called "single-chip microprocessor". This leads to considerable cost and volume reduction for the testing device.

The display device 24 has separate display fields 30 and 31, on the one hand for the display of the physical condition, characterized in figure 2 by A, B and C, and on the other hand for display of the charge state, characterized in figure 2 by 1, 2, 3. The display fields 30, 31 are selectively actuated by the operator 18 via the display device 24. Instead of the display fields 30, 31, it is also possible to hook up to the display device 24 a digital display, a band of consecutively lighting LEDs, a printer for text output, or the like.

The general power supply for the testing device comes through the tested unit 10, so that the testing device can be used anywhere, regardless of available power supply mains.

The mode of operation of the above-described testing device is as follows:

First, the tested unit 10 is connected to the testing device. After this, the tester must activate the starter 29. The testing of the tested unit 10 occurs spontaneously and a display field 30 and a display field 31 each light up in the display device 24, showing the physical condition of the tested unit and the charge state of the tested unit. For example, if the display field 30 lights up with "A" and display field 31 with "2", this means, e.g., that the physical condition of the tested unit, i.e., its storage capability, is the best it can be, i.e., it is a new battery, and the tested unit 10 is partly discharged. Accordingly, the display field 30 with "C" identifies a tested unit with very poor storage capacity and the display field 31 with "1" a completely charged unit 10.

Specifically, the following takes place during the testing procedure: the time switch 28 first sends a starting pulse to the high-current pulse generator 27, which as described above applies a high-current pulse to the tested unit 10. After this, the actual testing procedure begins with turn-on of the constant-current generator 12, likewise by a control pulse of the time switch 28. The time switch 28 with another pulse controls the analog switch 20 such that, e.g., the resistance measuring unit 11 is first connected to the analog/digital converter 19. The resistance measuring unit 11 measures the alternating voltage drop at the terminals of the tested unit 10 and applies this as an amplified analog signal to the analog/digital converter 19. This furnishes to the operator 18 a corresponding digital measured-value signal of the a.c. internal resistance of the tested unit, which is kept in the cache memory 21.

The analog switch 20 is switched by another control pulse of the time switch 28, so that now the input of the analog/digital converter 19 is connected to the output of the voltage measuring unit 14. The terminal d.c. voltage of the tested unit 10 is amplified via the d.c. voltage amplifier 15 and furnished as an analog measured-value signal to the analog/digital converter 19, which likewise puts out a corresponding digital measured-value signal of the no-load voltage of the tested unit 10 to the operator 18, where this is likewise kept in the cache memory 21. From the data entry device 26, the characteristic data of the tested unit 10 entered prior to the start of the testing procedure are entered into the calculator 22. By means of these characteristic data, the calculator 22 reads out from the two memories 16, 17 a characteristic functional relation of the no-load voltage U_B in dependence on the ampere-hour capacity Ah ($U_B = f(Ah)$) and a coordinated characteristic functional relation of the a.c. internal resistance R_S in dependence on the ampere-hour capacity Ah ($R_S = f(Ah)$) of a d.c. source which is the same type as the tested unit 10, and this for a d.c. source having the best physical condition, i.e., maximum storage

capacity. The calculator 22 now calculates or determines, with the measured value of the no-load voltage of the tested unit and the memorized functional relations, a coordinated value of the a.c. internal resistance and puts this out as the output signal, which is furnished to the comparator 23. The comparator compares this output signal with the measured value of the a.c. internal resistance, which is furnished to the comparator 23 from the cache memory 21. It is assumed that the comparator 23 at first establishes no coincidence or approximate coincidence of the two input signals, since the output signal of the calculator 22 is smaller than the measured-value signal of the a.c. alternating resistance. According to what was said above, the comparator 23 thus puts out an output signal to the controller 25, which in turn triggers a control signal that goes to the calculator 22. The control signal instructs the calculator 22 to again read out a characteristic functional relation $U_B = f(Ah)$ and the coordinated functional relation $R_S = f(Ah)$ from the two memories 16 and 17, but now for a physical condition of the same d.c. source that is one step worse. The calculator 22 determines with the functional relations now read out and still the same measured value of the measured no-load voltage of the tested unit 10 a new value of the a.c. internal resistance and puts this out as output signal to the comparator 23. If, now, this output signal is approximately equal to the measured-value signal of the a.c. internal resistance, the comparator 23 establishes a coincidence and, as described above, puts out a pulse to the display device 24. The number of the calculation or determination cycles performed by the calculator 22 is a measure of the physical condition of the tested unit 10, i.e., the more calculation cycles performed by the calculator 22, the worse the physical condition or the storage capacity of the tested unit 10. As soon as an output signal reaches the output of the comparator 23 connected to the display device 24, the display device 24 turns on one of the display fields 30 corresponding to the number of cycles of the calculator 22; here, for example, the display field "B", for two cycles of the calculator 22. This tells the person performing the test that the tested unit 10 has a reduced, but still adequate storage capacity. Since the Ah-value is automatically calculated or determined during the calculation or determination of the value of the a.c. internal resistance by the calculator 22, it is present at the display device 24 thanks to the connection between it and operator 18 and when the output signal arrives at the output of the comparator 23 that is connected to the display device 24 it can bring about the turn-on of a corresponding display field 31, e.g., the display field 31 with "2". This tells the person performing the test that the tested unit 10 is already partly discharged.

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Claims

1. Testing procedure for d.c. sources, like accumulators, batteries, etc., in which the a.c. internal resistance of the d.c. source being tested (the tested unit) is measured as a characteristic of its condition, characterized in that one also measures the no-load voltage of the tested unit (10) and by matching up the measured values of the no-load voltage (U_B), on the one hand, and the internal resistance (R_S), on the other, in correlated characteristic functional relations of the no-load voltage (U_B) in dependence on the ampere-hour capacity (Ah) and the a.c. internal resistance (R_S) in dependence on the ampere-hour capacity (Ah) for different physical conditions of a d.c. source of the same type as the tested unit (10), one obtains a separate verdict on the charge state, on the one hand, and physical condition, on the other.

2. Testing device for d.c. sources, like accumulators, batteries, etc., for carrying out the testing procedure of Claim 1, with a voltage measuring unit that measures the a.c. internal resistance of the tested unit and with a display device putting out the condition of the tested unit, characterized by a voltage measuring unit (14) that measures the no-load voltage of the tested unit (10), a first memory (16), in which are kept the characteristic functional relations of the no-load voltage (U_B) and the ampere-hour capacity (Ah) of at least one d.c. source of the same type as the tested unit (10) for various selected physical conditions of same, a second memory (17), in which are kept the characteristic functional relations of the a.c. internal resistance (R_S) and the ampere-hour capacity (Ah) of at least one d.c. source of the same type as the tested unit (10) for various selected physical conditions of same, an operator (18) connected to the resistance measuring unit (11), the voltage measuring unit (14), and the memories (16, 17), having a calculator (22), which calculates or determines a coordinated value of the a.c. internal resistance (R_S) from the memorized relations for the no-load voltage (U_B) of the tested unit (10) measured and arising as signal at the input of the operator (18), and a comparator (23), which puts out a display signal to the display device (24) connected to the operator (18) upon coincidence or substantially approximate coincidence between the a.c. internal resistance (R_S) measured and arising as signal at the input of the operator (18) and the output signal of the calculator (22).

3. Testing device per Claim 2, characterized in that the operator (18) has a controller (25).

which is designed such and connected to the comparator (23) and the calculator (22) such that the latter runs through a calculation or determination cycle with each control signal of the controller (25), wherein consecutive cycles occur, each with the memorized relations for a particular physical condition of the d.c. source, being read out in succession from the memories (16, 17), preferably starting with the relations for the best physical condition, and in the controller (25) a control signal is triggered for each difference of the input signal of the comparator (23).

4. Testing device per Claim 2 or 3, characterized in that a data entry device (26) is connected to the operator (18), by means of which the characteristic data of the tested unit (10), such as rated voltage, rated capacity, and type, can be put into the calculator (22).

5. Testing device according to one of Claims 2-4, characterized in that the operator (18) has a cache memory (21), which stores input signals corresponding to the measured no-load voltage (U_B) or the measured a.c. internal resistance (R_S).

6. Testing device according to one of Claims 2-5, characterized in that the voltage measuring unit (14) and the resistance measuring unit (11) are connected to the operator (18) via an analog switch (20) and an analog/digital converter (19).

7. Testing device according to one of Claims 2-6, characterized in that the resistance measuring unit (11) has a constant-frequency constant-current generator (12) that can be connected to the tested unit (10) and a voltage amplifier (13) that can be connected to the tested unit (10), which is preferably designed as a selective amplifier with d.c. gate that can be tuned to the frequency of the constant-current generator (12).

8. Testing device according to one of Claims 2-7, characterized in that the voltage measuring unit (14) has a d.c. voltage amplifier (15) that can be connected to the tested unit (10), at which an offset voltage is preferably applied.

9. Testing device according to one of Claims 2-8, characterized in that a high-current pulse generator (27) which can be turned on shortly before activation of the measuring units (11, 14) is provided, which can be connected to the tested unit (10).

10. Testing device according to Claim 9, characterized in that a time switch (28) putting out control pulses of different time is provided, being connected to the high-current pulse generator (27), the constant-current generator (12), and the analog switch (20).

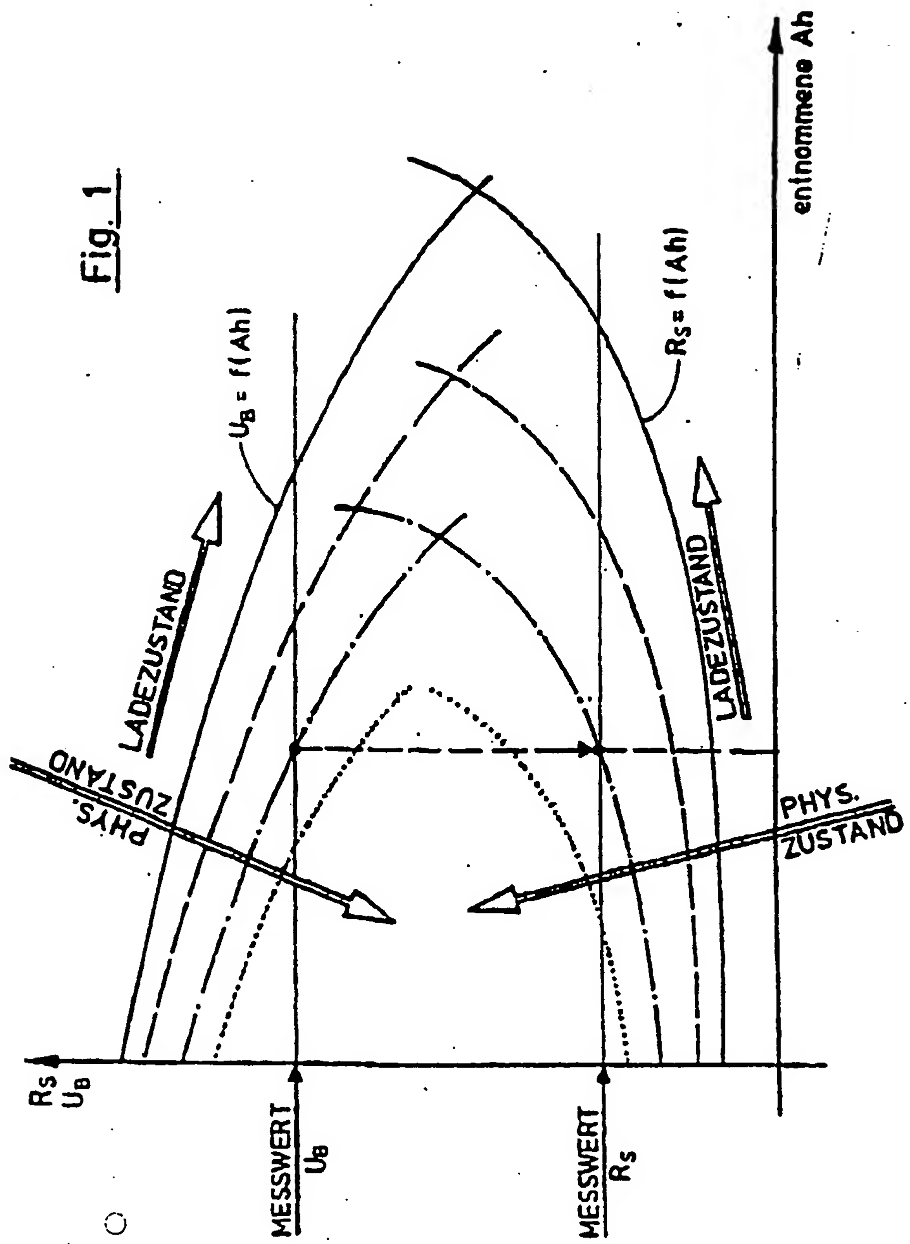
11. Testing device according to one of Claims 2-10, characterized in that the operator (18) is configured as a microprocessor.

12. Testing device according to Claim 10, characterized in that the operator (18), the memories (16, 17), the analog switch (20), the analog/digital converter (19), the time switch (28), and at least parts of the display device (24) are assembled in a single-chip microprocessor.

13. Testing device according to one of Claims 2-12, characterized in that the display device (24) has separate display fields (30, 31) for display of the physical condition and for display of the charge state of the tested unit (10), being selectively actuated by the operator (18).

Figure 1

key:
MESSWERT = measured value
PHYS. ZUSTAND = physical condition
LADEZUSTAND = charge state
entnommene Ah = Ah removed



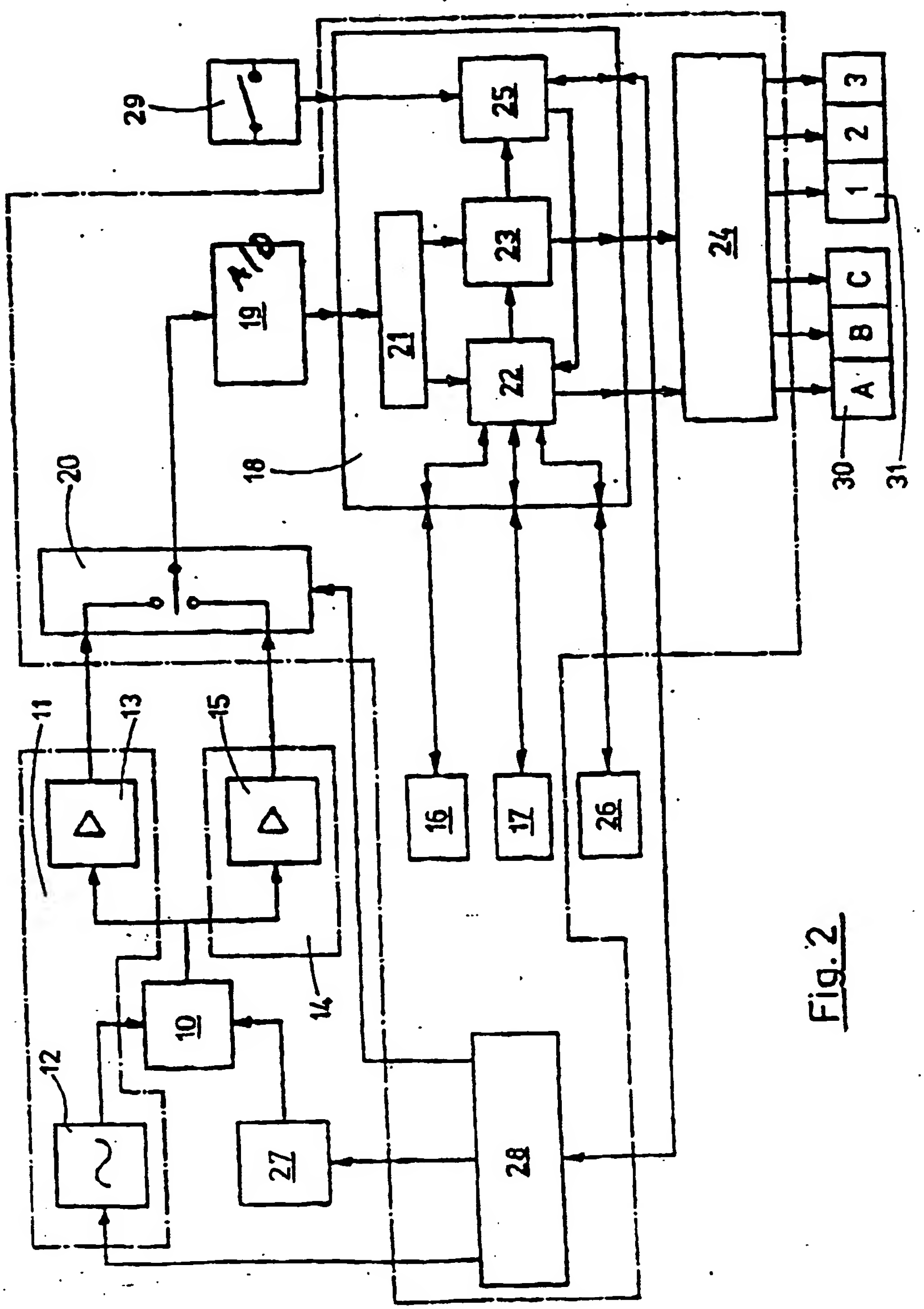

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Fig. 2

European Patent Office Application number:

EUROPEAN SEARCH REPORT

EP 80 10 1949.8

RELEVANT DOCUMENTS

Category	Title of document, indicating the critical passages as necessary	Re.: Claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
	DE - B2 - 2 244 285 (K.S. CHAMPLIN) * Column 4, Line 52 to Column 6, Line 47 *	1, 2	G 01 R 31/36 H 01 M 10/48
	BE - A - 776 529 (VARTA S.P.A. et at.) * Page 5, paragraph 4; figure 9 *	2, 3	
	RESEARCH DISCLOSURE, No. 167, March 1978 "Battery Condition Status Indicator" Page 14, Reference 16717		

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

G 01 R 31/00
G 01 R 31/36
H 01 M 10/48
H 02 J 7/10
H 02 J 7/14

CATEGORIES OF CITED DOCUMENTS

X: of special importance in itself
A: technological background
O: unwritten disclosure
P: intervening literature
T: theories or principles underlying the invention
E: older patent document, yet published only on or after the application date
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The present search report has been drawn up for all patent claims.

Place of Search:	Search completion date:	Examiner:
Berlin	20 Oct ber 1980	LEMMERICH